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Effectiveness of Project-Based and Case-Based Learning Models on Children's Numeracy Literacy Skills in Schools

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Abstract
There are many studies on project-based learning and case-based learning models in the world of Education, but many studies have concluded that the results of the research are different and the influence of the model is not profound on Children's numeracy skills. This study aims to determine the effectiveness of project-based and case-based learning models to improve Children's numeracy literacy skills in schools. The type of research is quantitative research with a meta-analysis approach. The eligibility criteria of this study are that the research must be relevant, the research data is obtained from the ScienceDirect database; Mendeley; ERIC and Google Scholar; The research was published in 2020-2025; and The research must report complete data to calculate the effect size value. Data analysis with the help of Excel and Jamovi applications to calculate the effect size value of each study. The results of the study concluded that the 19 studies analyzed obtained a summary effect size value ($d = 0.924$; $z = 7.446$ $p < 0.001$). These findings show that the project-based learning and case-based learning models have a significant influence on Children' numeracy literacy skills in schools.

Keywords: *PjBL; CBL; Effect Size; Numeracy Literacy*

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Introduction

Numeracy is one of the fundamental skills of the 21st century that has a crucial role in supporting individual success in various areas of life(Zulyusri et al., 2023; Asnur et al., 2024; Luciana et al., 2024). In the era of globalization marked by technological advances and economic complexity, numeracy literacy is not only related to the ability to count, but also includes the understanding, analysis, and application of mathematical concepts in solving everyday problems (Azubuike et al., 2024; Bulfone et al., 2024). Numeracy allows individuals to make better decisions, whether in personal, professional, or social contexts. For example, in the world of work, numeracy skills are needed to read data, analyze statistics, and manage resources efficiently (Johnston & Ksoll, 2022). In everyday life, numeracy literacy helps a

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person to understand numerical information such as financial reports, schedules, or even weather forecasts, thereby improving critical thinking and evidence-based decision-making skills (Kevin et al., 2025; Alban Conto et al., 2021).

In the context of modern education, the development of numeracy skills is a top priority because it is directly related to Children' ability to adapt to the demands of the world of work and a society that continues to develop (Zulkifli et al., 2022; Ali et al., 2024;Wantu et al., 2024). Various studies, such as PISA (Programme for International Student Assessment), show that numeracy literacy is an important indicator in evaluating the quality of education systems around the world (Murugiah et al., 2023; Nurtamam et al., 2023; Oktarina et al., 2021). Numeracy-based education not only equips Children with mathematical abilities, but also builds higher-order thinking skills, such as data analysis, problem-solving, and creativity (Bachtiar et al., 2023; Coman & Chereches, 2024; Flink et al., 2024). Therefore, education systems need to integrate numeracy comprehensively into the curriculum, both through conventional and innovative learning, to ensure Children are ready to face global challenges and are able to contribute productively in modern society (Happy et al., 2025).

The low numeracy literacy of Children at various levels of education is a serious challenge in the world of global education, including in Indonesia. Based on the results of international studies such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), Children' ability in numeracy literacy is still below the international average. The 2018 PISA report shows that the majority of Indonesian Children are at a low level of proficiency in mathematics, they are only able to answer basic questions that are straightforward without involving complex thinking (Jalinus et al., 2020; Tierney et al., 2022). Meanwhile, TIMSS results show a similar trend, where many Children have difficulty in applying mathematical concepts to solve contextual problems. These findings reflect Children' lack of mastery of basic numeracy skills, which should be the foundation for higher learning (Sahrir et al., 2012).

The problem of low numeracy literacy can be related to several factors, such as suboptimal learning approaches, lack of supporting facilities, and low teacher competence in integrating numeracy into daily teaching (Hizqiyah et al., 2023); Sisamud et al., 2023; Badawi et al., 2023). Many schools still use traditional learning methods that do not encourage Children to think critically and creatively in understanding the concept of numeracy. In addition, unequal access to quality educational resources also exacerbates the disparity in numeracy skills between regions(Aydın & Mutlu, 2023). This low numeracy literacy not only has an impact on Children' academic achievement, but also hampers their opportunities to compete in the world of work and face global challenges. Therefore, there needs to be a collective effort from governments, educators, and the education community to improve numeracy literacy through innovative learning strategies, teacher training, and the provision of adequate educational resources (Muhajir et al., 2024; Yim, 2024).

The low numeracy literacy of Children as reflected in various national and international studies confirms the urgent need for more innovative learning approaches (Azubuike et al., 2024). Conventional approaches that tend to be teacher-centered are often less effective in building Children' understanding of more in-depth and applicable numeracy concepts (Bulfone et al., 2024; Rupavijetra et al., 2022) Therefore, learning methods that are able to actively involve Children in the learning process are needed, such as Project Based Learning (PBL) and Case Based Learning (CBL). This learning model emphasizes real-world problem-based learning, allowing Children to integrate numeracy skills into everyday contexts (Plews et al., 2024); (Fitri et al., 2024; Widiastuti et al., 2024). By providing a relevant and interactive learning experience, PBL and CBL not only help Children understand numeracy concepts better, but also practice critical thinking, analytical, and problem-solving skills (Ichsan et al., 2023a).

Furthermore, innovative approaches such as PBL and CBL can also increase Children' motivation to learn, as they are directly involved in the process of exploration and problem-

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solving that suits their interests and needs. This approach provides space for Children to work collaboratively, develop creativity, and learn from practical experience (Cheerapakorn et al., 2024; Alban Conto et al., 2021). In the context of numeracy, Children are invited to analyze data, make number-based decisions, and solve problems using quantitative methods. This not only strengthens numeracy literacy, but also helps Children see the relevance and importance of these skills in real life. Therefore, the integration of innovative learning approaches is a strategic step to answer the challenge of low numeracy literacy of Children, as well as prepare them to face the demands of 21st century education (Luciana et al., 2024).

Project Based Learning (PBL) and Case Based Learning (CBL) are two innovative learning models designed to increase student engagement and develop higher-order thinking skills. PBL puts Children at the center of learning through the completion of projects that focus on real problems. In PBL, Children are encouraged to collaboratively design, analyze, and come up with creative solutions, which not only strengthens their understanding of the subject matter but also improves skills such as communication, time management, and decision-making (Murugiah et al., 2023). This approach is relevant to the demands of 21st-century learning, where Children need to have the ability to relate theoretical knowledge to practical applications in the real world. By providing a contextual learning experience, PBL helps Children understand concepts in depth and more meaningfully (Putri et al., 2021).

Meanwhile, CBL emphasizes case-based learning that encourages Children to analyze and solve complex situations drawn from real problems. This model is effective in developing Children' critical and analytical thinking skills because they must evaluate information, consider various perspectives, and make decisions that are based on strong data and arguments (Syawaludin et al., 2022). In an educational context, CBL allows Children to learn abstract concepts through relevant practical contexts, thereby increasing retention and comprehension. In addition, this model also encourages group discussions and teamwork, which can strengthen Children' interpersonal skills (Rupavijetra et al., 2022; Lubis et al., 2018; Tierney et al., 2022; Girgin, 2020). Both PBL and CBL, with their focus on active and experiential learning, provide an effective framework for preparing Children for future academic and professional challenges (Lim et al., 2023; Hizqiyah et al., 2023).

Previous research has shown that Project Based Learning (PBL) has a significant impact on improving Children' numeracy literacy. For example, research by Krajcik and Blumenfeld (2006) shows that through PBL, Children can understand mathematical concepts in more depth because they are involved in the exploration and application of numeracy in the context of real projects. This method allows Children to develop critical and analytical thinking skills through contextual problem-solving. In addition, research conducted by Çiftçi and Karaman (2018) found that the application of PBL not only improves Children' ability to understand the concept of numeracy, but also strengthens their learning motivation due to the relevance of learning materials to daily life. According to research by Herreid and Schiller (2013), the CBL model facilitates case analysis-based learning that requires Children to use numeracy skills in analyzing data and making decisions. The study found that Children who learned through CBL showed improved critical thinking skills and a better understanding of complex material. Another study by Flynn and Klein (2001) shows that the CBL approach encourages Children to be actively involved in discussions and collaboration, which ultimately helps them understand how numeracy is applied in a variety of professional and social contexts. Research by Kolodner et al. (2003) found that the integration between problem-based projects and case analysis can create a holistic learning experience, which strengthens Children' conceptual and applicative skills. Additionally, this approach provides Children with the opportunity to learn independently and collaboratively, so they can develop 21st-century skills such as communication, collaboration, and problem-solving.

While numerous studies have individually investigated the effectiveness of Project-Based Learning (PBL) and Case-Based Learning (CBL) in enhancing various learning outcomes, including numeracy skills, limited research has systematically examined their

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comparative effectiveness through a meta-analysis. Existing studies often focus on isolated comparisons, lack rigorous methodological standards, or do not specifically target numeracy literacy as an outcome. Moreover, there is a scarcity of research that synthesizes the findings from diverse contexts, considering factors such as student characteristics, teacher training, and implementation fidelity, which can significantly influence the effectiveness of these learning models. This meta-analysis aims to address the gap by systematically reviewing and synthesizing existing empirical research on the effectiveness of PBL and CBL in improving Children' numeracy literacy skills in schools. By using rigorous methodological procedures and comprehensive search strategies, this study will provide a stronger and nuanced understanding of the comparative effectiveness of these learning models.

Methodology

This study uses a meta-analysis approach to determine the the effectiveness of project-based learning and Cased-Based Learning models to improve Children' numeracy literacy skills in schools. Meta-analysis is a research approach that evaluates previous research statistically to reach a conclusion (Tamur et al., 2020; Badawi et al., 2023; Nurtamam et al., 2023; Zulyusri et al., 2023). The meta-analysis research procedure is 1) determining the research inclusion criteria, 2) collecting data and coding, 3) analyzing the data statistically.

Eligibility Criteria

In the process of searching for data through the Google Scholar, ScienceDirect, Wiley, ERIC, ProQuest, Fronteins and Web of Science databases, the research must meet several inclusion criteria, namely the research must be relevant, the research data is obtained from the ScienceDirect database; Mendeley; ERIC and Google Scholar; The research was published in 2020-2025; and The research must report complete data to calculate the effect size value. From the data search, 19 studies were obtained that met the inclusion criteria published in 2020-2024 which can be seen in Table 2.

Statistical Analysis

Data analysis in this study calculates the effect size value of each study analyzed. The effect size value in this study is to calculate the the effectiveness of project-based learning and Cased-Based Learning models to improve Children' numeracy literacy skills in schools. Analyze effect size values with the help of Microsoft Excel and Jamovi. According to (Borenstein et al., 2007) The stages of data analysis in the meta-analysis can be seen in (Figure 1.). Furthermore, the criteria for the effect size value in the study can be seen in Table 1.

Table 1. Category Effect Size Value

Effect Size	Category
0.0≤ES≤ 0.2	Low
0.2≤ES≤ 0.8	Medium
ES≥ 0.8	High

Source: (Borenstein et al., 2007; Bachtiar et al., 2023; Tamur et al., 2020); Dewanto et al., 2023)

Result and Discussion

Based on the results of data search through the database, 19 studies/articles met the inclusion criteria. The effect size and error standard can be seen in Table 2.

Based on Table 2, the effect size value of the 19 studies ranged from 0.29 to 2.80. According to Borenstein et al., (2007) Of the 19 effect sizes, 7 studies (36.84 %) had medium criteria effect sizes and 12 studies (63.16 %) had high criteria effect size values. Furthermore, 19 studies were analyzed to determine an estimation model to calculate the mean effect size. The analysis of the fixed and random effect model estimation models can be seen in Table 3.

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Table 2. Effect Size and Standard Error Every Research

Code Jurnal	Years	Effect Size	Standard Error
PN 1	2020	0.89	0.30
PN 2	2022	1.92	0.41
PN 3	2023	0.72	0.29
PN 4	2024	1.18	0.30
PN 5	2024	1.55	0.44
PN 6	2020	1.59	0.37
PN 7	2021	0.66	0.19
PN 8	2022	0.79	0.23
PN 9	2023	0.42	0.10
PN 10	2024	1.10	0.45
PN 11	2023	0.34	0.11
PN 12	2022	0.39	0.19
PN 13	2024	0.89	0.39
PN 14	2024	1.17	0.45
PN 15	2020	0.81	0.40
PN 16	2021	0.29	0.11
PN 17	2024	1.80	0.41
PN 18	2024	2.80	0.72
PN 19	2022	1.05	0.39

Table 3. Fixed and Random effect

	Q	df	p
Omnibus test of Coefficients Model	56.094	1	< 0.001
Test of Residual Heterogeneity	93.091	18	< 0.001

Based on Table 3, a Q value of 93.091 was obtained higher than the value of 56.094 with a coefficient interval of 95% and a p value of 0.001 <. The findings can be concluded that the value of 19 effect sizes analyzed is heterogeneously distributed. Therefore, the model used to calculate the mean effect size is a random effect model. Furthermore, checking publication bias through funnel plot analysis and Rosenthal fail safe N (FSN) test (Tamur et al., 2020; Badawi et al., 2022; Ichsan et al., 2023b; Borenstein et al., 2007). The results of checking publication bias with funnel plot can be seen in Figure 2.

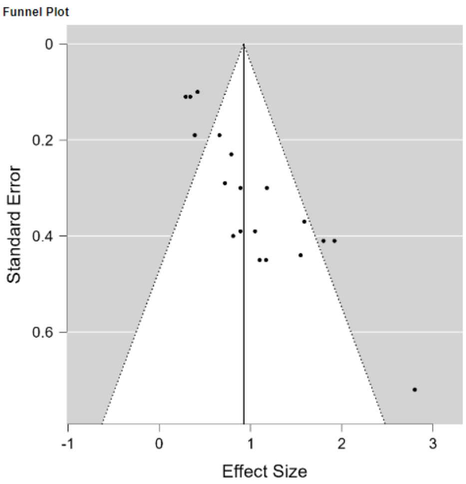

Figure 2. Funnel Plot Standard Error

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Based on Figure 2, the analysis of the funnel plot is not yet known whether it is symmetrical or asymmetrical, so it is necessary to conduct a Rosenthal Fail Safe N (FSN) test. The results of the Rosenthal Fail Safe N calculation can be seen in Table 4.

Tabel 4. Fail Safe N

File Drawer Analysis			
	Fail Safe N	Target Significance	Observed Significance
Rosenthal	1361	0.050	< 0.001

Based on Table 4, the Fail Safe N value of 1361 is greater than the value of 5k + 19 = 5(19) + 10 = 105, so it can be concluded that the analysis of 24 effect sizes in this data is not biased by publication and can be scientifically accounted for. Next, calculate the p-value to test the hypothesis through the random effect model. The results of the summary effect model analysis with the random effect model can be seen in Table 5.

Tabel 5. Summary/ Mean Effect Size

Coefficient						
	Effect Size	Standard Error	z	p	95 %BCoefficient Interval	
					Lower	Upper
Intercept	0.924	0.124	7.446	< 0.01	0.681	1.671

Based on Table 5, the results of the analysis with the random effect model obtained a lower limit value of 0.681 and an upper limit of 1.671 and a mean effect size value of 0.924 The effect size category in this study is included in the high category. Furthermore, the results of the Z test to determine the significance were obtained 7.446 and the p value < 0.01, so it can be concluded that the application of effectiveness of project-based learning and cased-based learning models The PjBL model allows Children to learn through projects designed to solve real-world problems. In the context of numeracy literacy, PjBL gives Children the opportunity to integrate mathematical concepts with real-world situations, such as budget planning, data analysis or designing number-based solutions(Williams, 2005; Schmidt et al., 2011). This process helps Children connect theory with practice, strengthen conceptual understanding and improve maths application skills. In addition, project-based learning involves teamwork which enriches the learning experience through discussion and exchange of ideas between members.to improve Children' numeracy literacy skills compared to the conventional model (Thistlethwaite et al., 2012; Yang et al., 2024).

In contrast, the CBL model emphasises in depth analysis of relevant case studies. It encourages Children to think critically, identify problems and seek solutions based on data and mathematical logic (Erfani & Frias-Martinez, 2023). In its application, CBL challenges Children to tackle complex scenarios, such as analysing statistical trends or making decisions based on key figures in a particular case study. This approach also helps Children to develop reflective thinking skills and improve their ability to make numerically-informed decisions. PjBL is more effective in enhancing Children' creativity and collaborative ability, while CBL is superior in encouraging critical analysis and systematic thinking ability (Hemphill et al., 2015). Therefore, the choice of learning model should be adjusted to the learning objectives and Children' needs. The combination of these two models can also be an effective strategy to improve numeracy literacy holistically (McLean, 2016).

PjBL and CBL have great potential in improving Children' numeracy literacy by providing contextualised, interactive and applicable learning experiences (Dzo'ul Milal et al., 2020). To ensure successful implementation, it is important for educators to design learning

activities that are relevant to Children' context, provide sufficient guidance, and create an environment that supports exploration and discussion (Linders, 2012). In addition, a continuous evaluation of the learning outcomes is needed to understand the extent to which these two models contribute to the development of Children' numeracy skills at school (Girgin, 2020; Putri et al., 2021).

Conclusion

From the results of this study, it can be concluded that the 19 studies analysed obtained a summary effect size value ($d = 0.924$; $z = 7.446$; $p < 0.001$). This finding shows that project-based learning and cased-based learning models have a significant effect on Children' numeracy literacy skills at school. The PjBL model is superior in developing creativity, collaboration skills, and numeracy application in real projects, while CBL is more effective in training Children to think critically and systematically through case study analysis. Both models provide contextualised and problem-based learning experiences that are relevant to Children' needs to face the challenges of everyday life and the world of work. This research implies that educators need to choose a learning approach that suits the specific objectives of numeracy literacy learning. The combination of PjBL and CBL can be an effective strategy to improve numeracy skills holistically, including creativity, collaboration and critical thinking skills. In addition, schools and education policy makers should support teacher training to integrate these innovative learning models in the curriculum. Thus, learning outcomes will not only focus on academic achievement, but also prepare Children with numeracy skills that are relevant and applicable in real life.

To optimize numeracy learning, the implementation of Problem-Based Learning (PBL) and Case-Based Learning (CBL) needs to be designed contextually and applicatively. In PBL, teachers can present real-world problems, such as household budget calculations or simple statistical data analysis, so that students are used to connecting mathematical concepts with daily life. Meanwhile, in CBL, students can be provided with data-driven case studies, such as comparing the prices of goods in various stores or analyzing population growth patterns, so that they can develop analytical and problem-solving skills systematically.

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